Chapter Three—SRA Performance Parameters

Arterial operational performance parameters should correlate system throughput with the effectiveness and safety of movement. The parameters should measure attributes which are sensitive to traffic systems management, as well as geometric and other types of strategies that may be employed to improve system performance. As measures of arterial performance, the indices should be characteristic of the varying conditions within each route and among the routes in the SRA system.

System Throughput

System throughput is the volume of traffic processed, expressed as a function of demand and capacity. Demand is characterized by the number of vehicles processed per lane per unit of time. Capacity is measured in terms of the number of vehicles that can be accommodated at acceptable speeds per lane under prevailing conditions. Thus, for each route segment, throughput is measured as the number of vehicles processed per lane per unit of time. Regardless of the number of lanes, or other physical or operational characteristics of a route segment, this throughput measure is functionally consistent. As a measure of vehicles per lane, it incorporates common identifiable and easily understood units. The method of computation is simple, and easily performed. Data requirements are accommodated through existing collection programs, with some expansion of coverage.

For purposes of monitoring SRA performance, system throughput can be expressed in terms of *persons* rather than *vehicles*. This is required to recognize the function of urban arterials in accommodating both public transit buses and private autos. Freight movement is also an important function, but is accounted for by differences in composition of the traffic stream. The conversion from vehicles to person travel can be accomplished through adjustment of vehicular traffic counts to reflect measured vehicle occupancy, and by increasing the resulting total to include counts of transit bus passengers.

An arterial throughput performance parameter could be described as follows:

$\text{Sys Throughput}_i = (\text{Vehicles per unit of time})_i \, / \, (\text{Number of Lanes Available})_i$

where i is any defined route segment(route segment defining characteristics are presented in Chapter 4).

For example, assume that the northbound peak hour traffic volume is 2,844 vehicles for a 4 lane urban arterial (two lanes each direction), 6.7 miles long. The system throughput for this route segment is:

$$2844 \text{ veh} / 2 \text{ lanes} = 1422 \text{ veh} / \text{lane}$$

The segment throughput can be aggregated to a route system throughput by computing the weighted average volume per route lane, as follows:

$$\text{Route SysThroughput}_r = \frac{\Sigma((\text{SysThroughput}_i) \times (\text{Segment Length}_i) \times (\text{No.Lanes}_i)}{\Sigma(\text{Segment Length}_i) \times (\text{No. Lanes}_i)}$$

An example calculation for a route composed of four segments is presented in Exhibit 3.1

Similarly, for the SRA system, the system throughput is computed as the weighted average volume per route lane for the total system, as follows:

$$\text{SRA SysThroughputr} = \frac{\Sigma(\Sigma(\text{SysThroughput}_i) \times (\text{Segment Length}_i) \times (\text{No.Lanes}_i))_r}{\Sigma(\Sigma(\text{Segment Length}_i) \times (\text{No. Lanes}_i))_r}$$

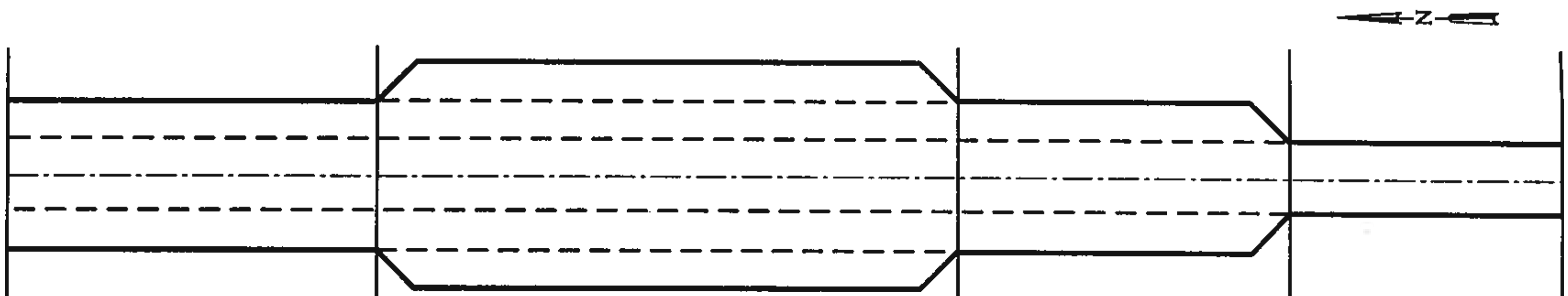
System throughput can be measured and characterized for several time periods such as the peak hour, peak period, or average day. Since the system throughput is measured on a route segment basis, comparisons can be performed among characteristic segments, e.g. two lane rural segment, four lane urban segments, etc. In this manner, performance can be evaluated on a variety of system structures using a common measure and can be employed to rank alternative locations for scheduled improvements. Similarly, this measure can be utilized for before and after studies of arterial improvements. System throughput can be measured on a route segment before and after implementing geometric, capacity, signalization, other operational or safety improvements.

System throughput performance can be presented graphically to depict historical trends. Examples are shown in Exhibit 3.2. The design criteria lane capacity (based on the recommended design criteria as presented in the "SRA Design Concept Report") is also often shown as a point of reference. Since, prevailing urban traffic conditions typically exceed desired conditions, a ratio comparing system throughput with design lane capacity is not recommended. This qualified volume to capacity ratio is not in itself sufficiently sensitive to changes resulting from operational performance strategies. This ratio is also misleading, in that ratios greater than 1.0 do not describe system performance. Thus, lane capacity based on design criteria should be considered as a relative benchmark and not a performance index.

On a given route segment, the magnitude of change in system throughput resulting from arterial improvement strategies which are localized or isolated, such as intersection or driveway turn prohibitions, may be insignificant. Operational performance changes resulting from isolated or localized improvements can be quantified by effectiveness of movement measures.

Effectiveness of Movement

Effectiveness of movement is a measure of how well traffic flows over a section of road. The unit of measure is time or speed, and is represented as the total travel time or the computed average speed inclusive of delays and time stopped along a designated segment or route, during a specified time period. Total travel time or average running speed, are both easily understood performance measures. The results produced are sensitive to a wide range of physical and operational strategies to improve arterial performance. The basis of measurement and procedures used to quantify total travel time or average running speed are consistent for each route segment in the SRA system.



LENGTH	6.7 mi (10.7 km)	8 mi (12.8 km)	4.5 mi (7.2 km)	4.2 mi (6.7 km)
NO. LANES	2 Each Direction	3 Each Direction	2 Each Direction	1 Each Direction
NORTHBOUND DIRECTION				
AM PEAK HOUR VOL. (vph)	2,168	3,416	2,320	1,866
AVG. DAILY TRAFFIC (vpd)	12,044	20,094	14,500	11,662
SEGMENT SYSTEM THROUGHPUT				
PEAK HOUR (vphpl)	1,084	1,139	1,160	1.866
AVG. DAILY (vpdpl)	6,022	6,698	7,250	11,662

ROUTE SYSTEM THROUGHPUT

PEAK HOUR (vphpl)

$$\frac{1{,}084\ (6.7)\ (2) + 1{,}139\ (8)\ (3) + 1{,}160\ (4.5)\ (2) + 1{,}866\ (4.2)\ (1)}{(6.7x2) + (8x3) + (4.5x2) + (4.2x1)} = 1{,}189$$

DAILY (vpdpl)

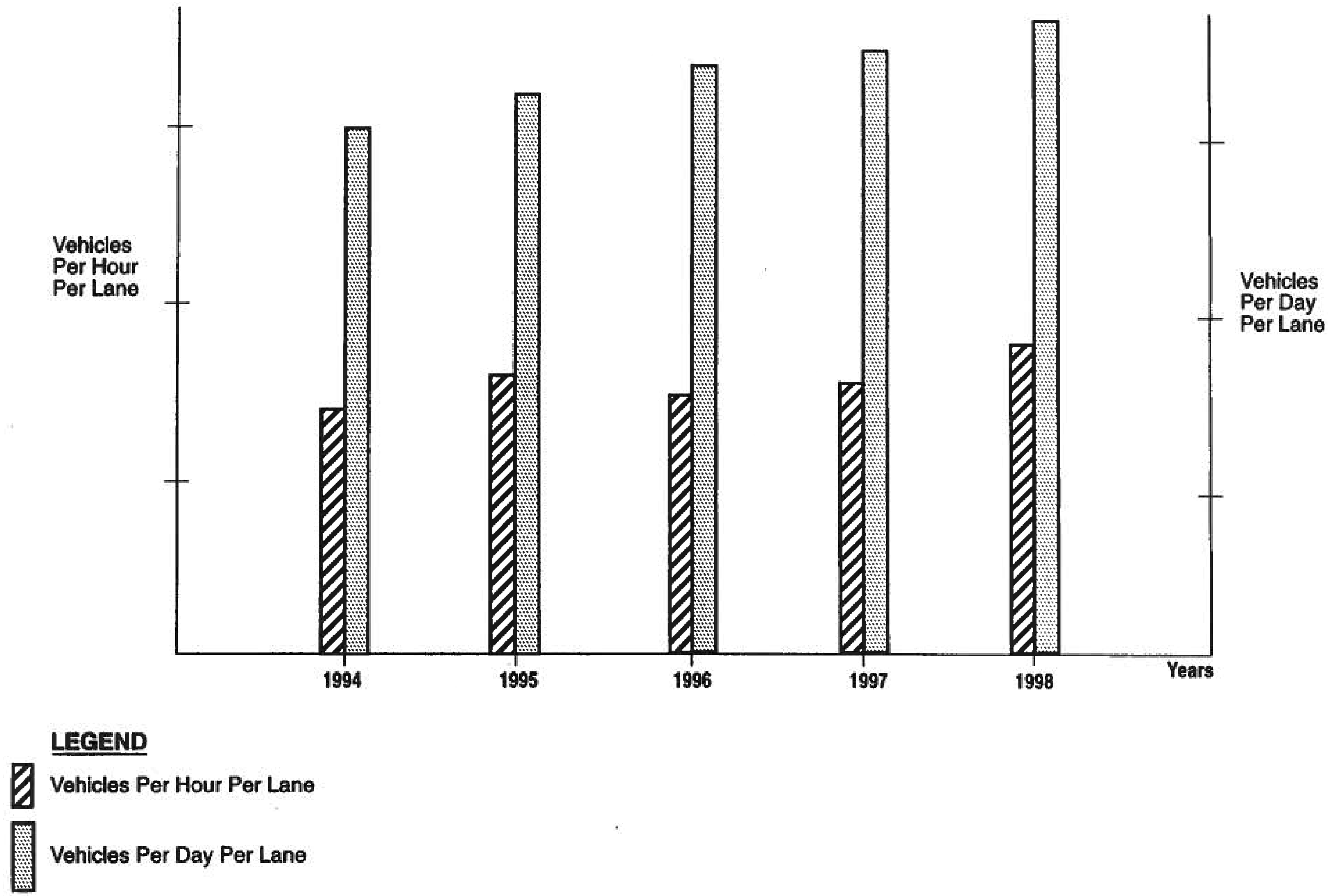
$$\frac{6{,}022\ (6.7)\ (2) + 6{,}698\ (8)\ (3) + 7{,}250\ (4.5)\ (2) + 11{,}662\ (4.2)\ (1)}{(6.7x2) + (8x3) + (4.5x2) + (4.2x1)} = 7{,}029$$

EXAMPLE CALCULATION OF SYSTEM THROUGHPUT

T104274.13.A4 Table 3.1 6-8-97 lg

Strategic Regional Arterial Planning Study

Exhibit 3.1



SYSTEM THROUGHPUT -- HISTORICAL TREND

Strategic Regional Arterial Planning Study

Exhibit 3.2

T104274.13.A4 Exhibit 3.1 6-6-97 lg

Effectiveness of movement is measured by one of several data collection techniques (which are described in the next chapter of this report). Total travel times are directly obtained by field measurements, whereas average running speed is computed by a simple calculation (dividing the distance traveled by total travel time).

At the segment level, the effectiveness of movement is defined as

$$EM_i = \text{Average Total Travel Time}_i$$

or

$$EM_i = \text{Average Running Speed}_i$$

where i is the individual segment, and EM is a weighted averaged over the number of field measurements taken.

For each SRA route, the effectiveness of movement is defined as the weighted average total travel time or average running speed.

$$EM_r = \frac{\Sigma((EM_i) \times (\text{Segment Length}_i))}{\Sigma(\text{Segment Length}_i)}$$

The SRA effectiveness of movement is defined as the weighted average total travel time or average running speed for the SRA system.

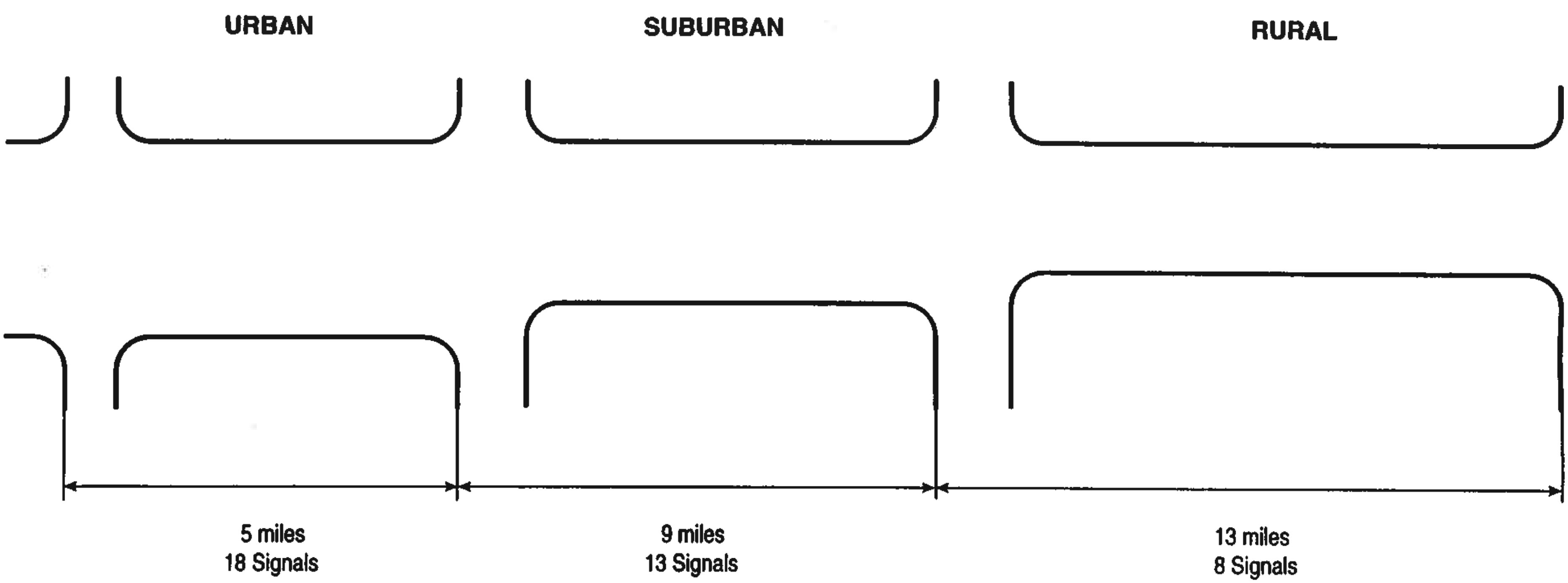
$$EM_{SRA} = \frac{\Sigma(\Sigma(EM_r) \times (\text{Route Length}_r)}{\Sigma(\text{Route Length}_r)}$$

Example calculations are presented in Exhibit 3.3 for urban, suburban and rural areas.

Total travel time or average running speed can be measured in one or more time periods such as the peak hour, mid-day peak hour or day-time off-peak period. The results can be tabulated by commonality of route segment, allowing for comparisons based on roadway characteristics, e.g. rural with one mile spacing between traffic signals or suburban with 1000 feet between traffic signals. Performance results can be used to compare and rank alternative locations for scheduled improvements, e.g. giving priority to those segments or routes where the total travel time during peak and mid-day periods is highest per unit distance traveled. Similarly, this performance measure can be used to test the significance of operational and geometric improvements through before and after studies at specific locations.

Benchmark comparisons can be made of actual total travel time or average running speed during peak periods or daytime off-peak periods versus the nighttime runs, where influences and delays due to traffic interaction are not present. Alternatively, benchmark comparisons can be made comparing total travel time or average running speed with the posted speed limit, or the design speed as defined in the SRA "Design Concept Report".

Not all SRA improvement strategies will result in significant changes in vehicle throughput or effectiveness of movement. In fact, some strategies may result in performance changes which are perceived negatively, such as increased travel time and or decreased vehicle throughput. Examples



TRAVEL TIME = 21 min
(5 mi @ 25 mph
+ 18 Signals @ 0.5 min)

TRAVEL TIME = 21.9 min
(9 mi @ 35 mph
+ 13 Signals @ 0.5 min)

TRAVEL TIME = 19.6 min
(13 mi @ 50 mph
+ 8 Signals @ 0.5 min)

TRAVEL TIME = 21 + 21.9 + 19.6 = 62.5 min (25.9 mph)

URBAN = 4.2 min/mi (14.3 mph)
SUBURBAN = 2.4 min/mi (24.7 mph)
RURAL = 1.5 min/mi (39.7 mph)

EXAMPLE CALCULATION OF EFFECTIVENESS OF MOVEMENT

T104274.13.A4 Table 3.3 0-8-07 lg

SRA Strategic Regional Arterial Planning Study

Exhibit 3.3

of these changes are signalizing an unsignalized intersection, or posting a lower speed limits. Yet, the proposed SRA strategies are indeed desired and necessary improvements. Thus a third performance measure is proposed. This measure focuses on safety and is a determinant in the needs based decision for operational and/or physical improvement strategies.

Safety

Safety is quantified in terms of accidents, by location, type and frequency of occurrence. For arterial routes, accidents should be categorized by three types: serious and/or fatal injury, minor with property damage, or pedestrian related. Serious or fatal injury accidents are those in which death resulted or hospitalization was required. Property damage or other accidents are those in which no hospitalization was required. Pedestrian related accidents are those which directly involve a pedestrian. Frequency of occurrence is typically related to vehicle miles traveled. For the SRA system, the following safety performance measures are proposed:

$$\text{Fatal Plus Injury Rate}_i = \frac{\text{Fatal and or Serious Injury Accidents in Segment i}}{[\text{Avg.Daily Traffic Vol.(Veh)}](\text{Route Length})/1{,}000{,}000}$$

$$\text{Total Rate}_i = \frac{\text{Total Reported Accidents in Segment i}}{[\text{Avg.Daily Traffic Vol.(Veh)}](\text{Route Length})/1{,}000{,}000}$$

$$\text{PED Rate}_i = \frac{\text{Pedestrian Related Accidents in Segment i}}{[\text{Avg.Daily Traffic Vol.(Veh)}](\text{Route Length})/1{,}000{,}000}$$

where i is the segment, and the number of accidents are totals for the preceding 12 months.

Safety performance measures for arterial routes are computed as follows:

$$\text{Fatal Rate}_r = \Sigma(\text{Fatal Rate}_i)$$

$$\text{Total Rate}_r = \Sigma(\text{Total Rate}_i)$$

$$\text{PED Rate}_r = \Sigma(\text{PED Rate}_i)$$

For the SRA route system, safety performance measures (accidents by type per million vehicle miles traveled) are summed by route for all routes in the SRA system.

$$\text{Fatal Rate}_{SRA} = \Sigma(\text{Fatal Rate}_r)$$

$$\text{Total Rate}_{SRA} = \Sigma(\text{Total Rate}_r)$$

$$\text{PED Rate}_{SRA} = \Sigma(\text{PED Rate}_r)$$

where r is the route totals.

Safety performance can be historically tracked to identify trends on characteristic arterials and/or segment types. Similarly, safety performance measures can be compared to regional or national accident rates. Examples of comparative rates for several characteristic roadways are presented in Table 3.1

The use of benchmark values from state records is preferred. Research and experience have shown that differences in reporting levels, methods of maintaining and updating accident records, and integration with other data bases all vary from state to state.

For monitoring the safety performance of SRA's, we recommend the use of rates or averages from IDOT. For those SRA's on the state system, reasonable historic information exists. IDOT is one of 11 state DOT's that participate in the FHWA's Highway Safety Information System (HSIS), a detailed database of accidents and roadway geometry. John Blair of IDOT's Safety Division is the HSIS liaison.

For SRA's within county or local jurisdiction, IDOT's state-wide averages will be useful, but care should be taken in direct comparison. It should be a long range objective of SRA Performance Monitoring to achieve consistency in the reporting, maintenance and analysis of safety data.

Table 3.1
Accidents by Road Type

Location and Road Type	Accidents (Number per Million Vehicle Miles)			
	Fatal	Injury	Property Damage Only	Total
Rural				
• No Access Control – Four or More Lanes, Divided	0.063	0.77	1.25	2.09
• Partial Access Control – Divided Expressway	0.038	0.44	0.76	1.24
Urban				
• No Access Control – Four or More Lanes, Undivided	0.040	2.12	4.49	6.65
– Four or More Lanes, Divided	0.027	1.65	3.19	4.86
Suburban				
• No Access Control – Four or More Lanes, Undivided	0.037	1.58	3.31	4.93
– Four or More Lanes, Divided	0.030	1.10	2.24	3.37
• Partial Access Control – Divided Expressway	0.060	0.82	1.29	2.16

Source: A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements. American Association of State Highway and Transportation Officials. 1977.

Flexibility of Performance Measures

Over time, the recommended performance measures may change. For example, if operational strategies were employed to increase vehicle occupancy during peak period traffic, then vehicle occupancy or person-trip based measures would be critical. The performance measures presented anticipate some of the potential unit changes, and can be easily modified to reflect new performance criteria. Throughput measures can be expressed in vehicles, persons, transit vehicles, or other appropriate units.

Effectiveness measures can be expressed in total travel time, running time, transit vehicle running time, transit vehicle travel time, or other appropriate measure. Similarly, safety measures can be expressed in terms of specific types of accidents, specific locations of accidents, specific frequencies of accidents, among others.